Navigation and Guidance

(Course Code: AE 410/641)

Department of Aerospace Engineering
Indian Institute of Technology Bombay

Instructor: Shashi Ranjan Kumar Autumn 2018-19

Deadline: **04 November 2018**

Assignment - 2

Total Points: 100

Instruction

- Assignment needs to be submitted online in pdf format on Moodle.
- If assignments are found to be copied from each other then both students will be awarded zero mark.
- If any data is missing then assume suitably and proceed accordingly.
- Simulation codes for generating all the necessary plots must be submitted.
- By running your submitted codes, the desired plots must be generated else you will not get marks for the same.
- I may ask you to explain your simulation code to me in person.

1. Assume that a missile is launched from surface of the earth while an aerial target is located at a horizontal distance of 8 km and at a height of 6 km above the surface. A schematic representation of engagement is shown in Fig. 1. The target is moving in horizontal direction receding away from missile at speed of 500 m/s. Assume that the missile is launched at a speed of 1000 m/s at an angle of 60° with the horizontal reference.

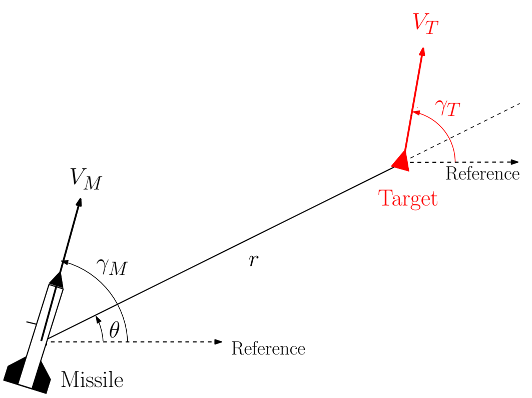

Figure 1: Planar Engagement Geometry

(a) Compute the LOS rate and closing speed, and missile's heading angle error.

(b) What would happen if the target moves towards the missile at a flight path angle of 150° with the reference? [10+10 Points]

2. Consider an engagement scenario, shown in Fig. 2, where missile is 10 km away in radial direction from the target and their line-of-sight (LOS) angle is 30°. Assume that the speed of missile and target are 500 m/s and 300 m/s, respectively, and the target has a flight path angle of 120°. The missile's autopilot is assumed to be perfect.

   (a) Plot the evolutions of trajectories of missile and target (*Use square and equal axes for better visualization of trajectories*) when missile uses pure pursuit guidance from the launch itself. Also, plot the required guidance command with respect to time.

   (b) What changes do you expect if the speed of target reduces to 250 m/s? Justify with the plot of missile's lateral acceleration, and trajectories of missile and target.

   (c) Compare the plots of trajectories and guidance command for deviated pursuit guidance corresponding to deviations $\delta = 10°,\ 20°,\ 30°$, and comment on your observations.

   (d) Suppose the missile is not in pure pursuit course from beginning but has an initial deviation of 30° anticlockwise in its velocity direction. How will you implement pursuit guidance law? Generate plots of trajectories and guidance commands accordingly. [10+10+10+10 Points]

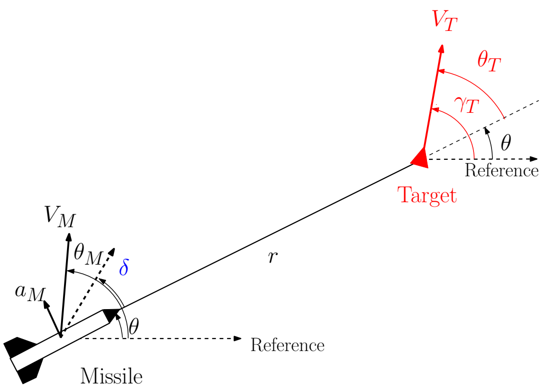

Figure 2: Planar Engagement Geometry for Pursuit Guidance

3. Consider an engagement scenario where missile and target are launched from ground and has a separation of 15 km. Assume that the speed of missile and target are 500 m/s and 300 m/s, respectively. The target is moving at an angle of 90° from the ground. The missile's autopilot is assumed to be perfect and target is non-maneuvering.

   (a) Compute the launch angle of missile such that it is on collision course with target from the beginning of engagement.

 Question 3 continues on the next page. . .

(b) If the missile is launched with heading angle error of $\pm 20°$, then plot the trajectories of missile and target using both RTPN and PPN guidance laws.

(c) Study the effect on trajectories and guidance command for various values of navigation constant $N = 2, 3, 5, 10$ in both cases of RTPN and PPN, and comment on your observations. [10+15+15 Points]

Hint: For simulation purpose, assume the missile and the target to be the point mass vehicles. Also, use the cartesian coordinate system for propagation of missile and target states. Assume that the position of missile and target are denoted by pairs (X_M, Y_M) and (X_T, Y_T), and their flight path angles are denoted by γ_M, γ_T, respectively. The lateral acceleration of missile and target are denoted as a_M and a_T, respectively. The missile and target kinematics in Cartesian coordinate system is given by

$$\begin{aligned}
\dot{X}_M &= V_M \cos \gamma_M \\
\dot{X}_M &= V_M \sin \gamma_M \\
\dot{X}_T &= V_M \cos \gamma_T \\
\dot{X}_T &= V_M \sin \gamma_T \\
\dot{\gamma}_M &= \frac{a_M}{V_M} \\
\dot{\gamma}_T &= \frac{a_T}{V_T}
\end{aligned}$$

where V_M and V_T denote the speed of missile and target, respectively. The missile-target distance, LOS angle, and other relevant variables can be computed using the positions of missile and target.